Summary of "Is Mortality Associated With Physician Volume, Specialist Certification, or Health Care Organization After Hospitalization for Community-Acquired Pneumonia?"

By T.J. Marrie, K.C. Carrière, Y. Jin, and D. Johnson

- Deaths one year after admission were decreased in hospitals that saw many pneumonia patients and in metropolitan (Edmonton and Calgary) hospitals.

Conclusions

Mortality in patients hospitalized for pneumonia is mostly related to the patient's degree of illness. Some other influences are also important - one being physicians that saw many pneumonia patients had less patient deaths than would have been expected. Hospitals that wish to improve outcomes in patients with pneumonia need to support either the physician's ability to care for many pneumonia patients or physicians treating patients similar to the practice style of these high volume physicians.

For more information

Copies of the report are available from the

Alberta Centre for Health Services Utilization Research

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- at http://www.health.gov.ab.ca/system/key/Research/achsur_reports.html

Alberta Centre for Health Services Utilization Research

The Alberta Centre for Health Services Utilization Research is a joint initiative between the University of Alberta and the University of Calgary, funded by Alberta Health and Wellness. The Centre conducts studies of how health services are used and delivered to inform health policy development and management of health services delivery.

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Purpose

This study looks at the relative importance of different influences (patient, physician, hospital organization) upon mortality in hospitalized patients with community acquired pneumonia. Patient influences included the severity of pneumonia and the presence of other co-existing diseases while physician influences included whether a specialist provided care, if a physician visit occurred within two weeks prior to hospitalization, if a specialist saw the patient in hospital, and if the physician who cared for the patient also saw many patients with pneumonia. Hospital organization influences included how far the patient traveled from home to hospital, the number of beds in the patients home region, how busy the hospital was on the day of admission, the hospital location, and volume of patients with pneumonia admitted.

Approach

Information from Alberta Health and Wellness hospital records and physicians billing claims between April 1, 1994 and March 31, 1999 were used in this study.

Key findings

The following are key findings of this study:

- Pneumonia death rates were high (eleven percent of hospital admissions died while in hospital and twenty-six percent died one year after admission).
- Sicker patients with more complicated pneumonia and patients that had other co-existing diseases died more frequently.
- Experienced physicians (those that saw more in-hospital pneumonia patients) had a lower rate of patient deaths than would have been expected considering the severity of pneumonia and other associated patient conditions.
- Physician experience in treating many pneumonia patients was more important than if the physician was a specialist physician or general practice physician (although eighty percent of high volume physicians were specialists).
- Where patients were treated, how busy the hospital was, how far patients had to travel from their home to hospital, what time of day or weekday/weekend day the patient was admitted were not strong influences in explaining patients in-hospital deaths from pneumonia.

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SUMMARY

We studied the relative importance of different influences (patient, physician, hospital organization) upon mortality in hospitalized patients with pneumonia. Patient influences were the severity of pneumonia and the presence of co-existing other diseases. Physician influences were defined as an internal medicine specialist provided care, if a physician visit occurred within two weeks prior to hospitalization, if a specialist saw the patient in hospital, and if the physician who cared for the patient also saw many patients with pneumonia. Hospital organization influences were how far the patient traveled from home to hospital, number of hospital beds per capita in the patient's home region, how busy the hospital was on the day of the pneumonia admission, was the hospital located in a metropolitan city, and did the hospital admit many patients with pneumonia. The study used hospital records and physicians billing claims from April 1, 1994 to March 31, 1999.

During the five study years there were 43,642 hospitalizations with an eleven percent in-hospital and twenty-six percent one year mortality. Patient severity and comorbidity were the strongest predictors of increased mortality. Physicians with the highest in-hospital pneumonia patient volume (more than twenty-seven per year) cared for patients with greater severity/comorbidity but with decreased chance of in-hospital mortality compared to the lowest volume physicians (less than seven patients per year). The effects of internal medicine specialist care were inconsistent with risk reduction for first seventy-two hours deaths and risk enhancement for all in-hospital deaths. A physician pre-hospitalization visit was associated with decreased mortality at seventy-two hours and for the entire hospital stay. Health care organization was the least strong predictor of mortality demonstrating its effect only for one year mortality in those discharged alive from hospital. Admission to larger volume or metropolitan hospitals was associated with decreased mortality.

We concluded that mortality in patients hospitalized for pneumonia is mostly related to the patient's degree of illness. Some other influences were also important. Being treated by a physician who saw many pneumonia patients was associated with fewer patient deaths than would have been expected. Hospitals that wish to improve outcomes in patients with pneumonia need to support either the physician's ability to care for many pneumonia patients or help lower volume physicians treat patients similar to the practice style of the high volume physicians.

INTRODUCTION

Community-acquired pneumonia is a common reason for hospital admission [1, 2]. Algorithms to help clinicians decide upon hospital admission and discharge have been devised, validated, and published [2-6]. These guidelines are robust [7] and may decrease mortality [8]. Despite clinical guidelines, considerable variation exists in the treatment of community-acquired pneumonia within larger Canadian hospitals [9]. Health care financing administration state peer review organizations have also documented variations in the processes of care for hospitalized community-acquired pneumonia [10] which directly impact upon patient outcome [10, 11]. All these studies address quality of care issues at the level of the clinician-patient interaction. Fewer studies explore the role of the health care organization which supports the patient-clinical interaction and may also be a factor in explaining patient outcomes.

This study attempts to quantify the relative strength of associations between mortality for hospitalized community-acquired pneumonia and patient factors (severity of illness, comorbidity), physician factors (specialty training, pre-hospitalization visit, in-hospital consultation, volume of patients seen per physician), and health care organization factors (patient travel distances, regional beds per capita, admitting hospital bed occupancy, admitting hospital bed turnover, hospital location, volume of pneumonia cases per hospital, season/day/time of admission). The association of all these factors to in-hospital mortality and one year mortality for hospital survivors is described. We used administrative data from April 1, 1994 to March 31, 1999 to study the entire scope of rural and urban hospital practice in one Canadian province.

METHODS

Defining Pneumonia and Data Extraction:

Three administrative health service databases were used and the analysis was done within the protected environment of Alberta Health and Wellness which is governed by provincial legislative guidelines on the confidentiality of health information.

- Canadian Institute for Health Information's Inpatient Discharge Abstract Database for the province of Alberta for 1994/95 to 1998/99,
- Alberta Physician Claims Assessment System Database for 1994/95 to 1999/00,
- Alberta Health Insurance Plan Registry File for 1994 to 2000.

Inclusion Criteria:

Community-acquired pneumonia was defined as the most responsible diagnosis (MRD) or any of the other fifteen diagnosis codes defined to be Type 1 (pre-admit comorbidity) with the ICD-9-CM values of 480.x to 487.x (pneumonia) or 507.x (aspiration pneumonia) excluding 484.x (pneumonia of infectious diseases classified elsewhere) [12, 13] found in Canadian Institute for Health Information's Discharge Abstract Database.

Exclusion Criteria:

1. Not an Alberta resident or not treated in an Alberta acute care facility
2. Adjacent diagnosis related group (ADRG) defining hospitalization for a surgical procedure
3. Any previous hospitalization within ten days of incident pneumonia case

Physician visits for community-acquired pneumonia were extracted from the Alberta Physician Claims Assessment System Database. Physician visits were defined as consultation claims (CPX 03.x)[14] between two to fourteen days prior to admission date with the most responsible diagnosis of community-acquired pneumonia (as defined above). All physician characteristics were extracted from hospital abstracts.

Patient Factors:

Demographic and comorbidity factors

- Age (18 to 44, 45 to 64, 65 to 74, 75 to 84, or 85 or more years (age at the fiscal year end is used)),
- Sex,
- Aboriginals registered with the Department of Indian Affairs and Northern Development are recorded within the Alberta Health Care Premium Registry databank,
- Urban or non-urban region of residence,
- Charlson's comorbidities were extracted using established definitions and each of twelve diagnostic categories compiled as none, one, two, more than two [15, 16].

Severity of illness factors

- Transfer to hospital from a nursing home, long term care or continuing care institution,
- Transfer to hospital by ambulance as defined in hospital abstract,
- Admission from emergency room as defined in hospital abstract,
- Emergent admission from home/office/clinic as defined in hospital record abstract,
- Special (intensive) care unit admission (as defined by each hospital),
- Diagnosis code of respiratory failure or arrest (ICD-9-CM 518.81, 799.1),
- Diagnosis code of hypotension or shock (ICD-9-CM 458.xx, 785.5x),
- Procedure code for ventilation greater than 96 hours (ICD-9-CM 96.72),
- Procedure code for dialysis (ICD-9-CM 39.95, 54.98)

Physician Factors:

- General/family practitioner listed as most responsible hospital physician,
- Any internal medicine specialist listed as consultation physician,
- Annual volume of pneumonia cases per physician (by quartile rank) including any hospital consultations and most responsible hospital physician,
- Pre-admission ambulatory visit (physician claims CPX 03.x) by any physician two to fourteen days prior to admission date with the diagnosis code for pneumonia as defined above,
- Pre-admission ambulatory visit (physician claims CPX 03.x) by an internal medicine specialist two to fourteen days prior to admission date with the diagnosis code for pneumonia as defined above,
- Any emergency room visit between two to fourteen days prior to admission date with the diagnosis code for pneumonia as defined above.

Physician specialty was coded in the hospital abstract.

Health Care Organization Factors:

- Admission to a hospital not within patient's defined health region of residence (see below),
- Transfer from smaller to larger acute care facility (see below) for the diagnosis of pneumonia as defined above,
- Remote distance to hospital (see below),
- Hospital volume (see below),
- Hospital beds per capita in the hospital's health region. All active acute care hospital beds in each year per health region were surveyed and maintained in the provincial databases,
- Bed turnover defined as the ratio of all hospital admissions per hospital bed in the specific hospital on the date of pneumonia admission,
- Occupancy rate defined as the daily census per hospital bed in the specific hospital at the date of pneumonia admission,
- Weekend (Saturday/Sunday/statutory holiday) admission date,
- Admission time between 18:00 to 08:00,
- Admission in December 1 to March 31 time period (peak season for pneumonia hospital admissions in Alberta).

Derived Variables:

Defining hospital type by patient volume:

All hospitals in Alberta are administered by an autonomous regional board in each of the seventeen health regions. All three million residents of Alberta are enrolled in the public health care insurance plan and reside in one of the seventeen health regions. Hospitals admitting patients with community-acquired pneumonia were categorized into five groups on the basis of the average number of separations per year over the five year study period, geographic location, and medical school proximity:

Rural

- Less than fifty cases per year comprising seventy-seven hospitals;
- Fifty to 108 cases per year comprising twenty-seven hospitals;

The rural hospital cutoff values for pneumonia cases of 50 and 108 represented the 50^{th} and 75^{th} percentiles of the volume of pneumonia cases in all Alberta patients.

Regional

- Five hospitals located in one of the five non-metropolitan regional health care cities ranging from 67 to 251 cases per year and one high volume rural hospital accounting for 221 cases per year;

Metropolitan

- Seven hospitals located in the metropolitan health regions of Calgary and Capital hospitals ranging from 92 to 813 cases per year;
- Two hospitals located adjacent to medical schools with one hospital in each of two metropolitan centres ranging from 493 and 610 cases per year.

Calculating Remote Distance to Hospital:

Each separation was mapped to the centre of a postal code and distances as the "crow flies" between centroids calculated. Nearest hospital distance to resident postal code was obtained for all non-urban residents. Urban resident distances were zero. Distances greater than fifty kilometres were defined as remote.

Mortality:

Vital statistics declaration of death certificates were merged with the Alberta Health Care Premium Registry databank in order to determine de-registration from the plan. Reliability of linkage was high (99.5 percent) as verified by comparing in-hospital deaths recorded by hospital chart extraction to Alberta Health Care Premium Registry death derived from vital statistics.

Outcomes Used in Regressions:

- In-hospital death per separation within the first seventy-two hours of admission;
- In-hospital mortality per separation;
- One-year mortality per separation in those not dying in hospital.

STATISTICS

A forward stepwise selection of factors was used to determine the order of importance of the factor influencing mortality. The factors were grouped as [1] patient severity of illness and comorbidity group, [2] health care organization group, or [3] physician group. As well, each entire factor group was forced in the model sequentially and c-statistic determined. The c-statistic is a summary rank correlation statistic between the observed responses and predicted probabilities, which equals the area under the receiver operator curve and is commonly reported for risk-adjustment models.

The unit of analysis was hospital discharge with some patients being hospitalized on multiple occasions per year. We attempted to adjust for correlations in hospital discharges within the same subject, but it did not result in substantial difference from those under the assumption of zero correlation. Therefore, we opted to report results of

a simpler approach based on multiple logistic models [18, 19]. To control the large sample size effect on statistical significance, we used one-third random sample from the separations data for statistical modeling [20]. The results were validated with the entire data to test for bias in the sample. Data was analyzed using the program SAS 8 [SAS Institute Inc. Cary, NC, 2000] and significance was defined as $p < 0.05$

RESULTS

During the five years of the study there were 43,642 acute care hospital discharges. The in-hospital mortality per hospital discharge was eleven percent (9.2 percent in the first twenty-four days as shown in Figure 1) and the overall one year mortality per hospital discharge was twenty-six percent. Out of 4,693 in-hospital deaths, 11.5 percent (538) died within twenty-four hours of admission, 16.5 percent (773) within twenty-five to seventy-two hours of admission, 45.0 percent (2,111) within seventy-three hours to two weeks of admission, and 27.1 percent (1,271) died beyond two weeks of admission.

As illustrated in Table 1, mortality was proportionally higher in males, older patients, those of urban residence, and those with comorbidity (in particular malignancy, congestive heart failure, vascular diseases, dementia, and renal disease - these data not shown). As illustrated in Table 2, the severity of illness markers identified proportionally higher mortality except for seasonal admissions. Severity of illness tended to be greater for deaths within seventy-two hours compared to all in-hospital deaths. As illustrated in Table 3, mortality was proportionally greater in urban hospitals and hospitals with proportionally greater mortality were located closer to patients' home residence. The median daily hospital occupancy rate was seventy-five percent (interquartile range fifty-six percent to ninety percent). The median number of daily admission per bed was 0.15 (interquartile range 0.1 to 0.2). As illustrated in Table 4, mortality was proportionally greater when internal medicine specialists were involved in the care either as the most responsible physician or consultant. The mean number of hospitalized community-acquired pneumonia patients per most responsible unique physician was 7.4 per year; these were grouped into quartiles (first quartile= 0-6 patients per year, second quartile= 7-13 patients per year, third quartile= 14-27 patients per year, and fourth quartile= more than 27 patients per year). Mortality was proportionally greater in those without a physician consultation in two to fourteen days prior to admission. Mortality was proportionally greater in those admitted directly from the emergency room, but not in those with an emergency visit in two to fourteen days prior to admission.

Table 5 demonstrates the relationships between physician volume, physician specialty, and patient comorbidity/severity of presentation. Internal medicine specialist and higher volume physicians cared for patients with greater severity of

presentation and greater comorbidity. Similarly, pre-admission consults by internal medicine specialists (but not for general practice physicians) occurred in patients with greater severity of presentation and more comorbidity. General practice physicians constituted eighty-four percent, eighty-eight percent, eighty percent, nineteen percent respectively of each of the four physician volume quartiles.

Tables 6a - 6c report the regression results. In-hospital mortality (both first seventy-two hours and all deaths) and one-year mortality of those discharged from hospital alive is described. The c-statistics for pneumonia mortality models ranged between 0.77 to 0.79, where a value of 1 equals perfect prediction and 0.5 prediction no better than by chance [17]. The patient factor group provided the best prediction of the mortality probabilities within seventy-two hours in terms of model entry order and c-statistic (Table 6a). Physician factors associated with decreased mortality within seventy-two hours were a non-specialist most responsible physician and specialist consult (during or prior to admission). None of the hospital care organization factors were significant.

Similar results were noted for all in-hospital deaths with respect to patient factors (Table 6b). In this case, physician factors demonstrated decreased in-hospital mortality with higher patient volumes for most responsible physician. Consults with an internal medicine specialist prior to admission were still associated with deceased in-hospital mortality but an in-hospital consultation was associated with increased in-hospital mortality. Compared to the patient factor group, the physician factor group provided less power of model prediction in terms of model entry order and c-statistic. Health care organization factors (timing of admission) became significant in predicting in-hospital death.

Patient factors provided the greatest power of prediction for one year mortality of those discharged from hospital alive (Table 6c). In-hospital specialist and high volume physicians were associated with increased mortality. Health care organization factors were significant but had the least predicting power of death within a year. Admission to a hospital not in region of residence was associated with increased mortality, while admission to larger volume or metropolitan hospitals was associated with decreased mortality.

DISCUSSION

This study explored the association of mortality with patient factors, physician factors, and health care organization factors after admission to hospital with community-acquired pneumonia. Mortality rates were eleven percent in-hospital and twenty-six percent at one-year [3]. As expected, severity of illness and comorbidity had the strongest association with mortality [21]. This paper is the first study associating high volume physician care with decreased in-hospital mortality for community-acquired pneumonia. Presence of internal medicine specialists was not consistently associated with decreased hospital mortality except when a pre-admission consultation occurred. Health care organization factors were weakly associated with in-hospital mortality for the acute episode and mortality in those that were discharged alive after the initial index episode of pneumonia. One-year mortality was decreased in high volume hospitals, where the original admission occurred.

The relationships between specialist, high volume practice, and more complex (greater severity of illness and comorbidity) patients are not easily separable. Specialists practice in higher volume centres and see the more complex patients on referrals. Thus any remaining confounding due to patient selection bias towards severe illness/comorbidity would tend to lower mortality associated with general practice physicians, while it increases mortality associated with specialists and high volume physicians.

Randomized trials comparing high/low volume, general/specialist practice are logistically difficult considering the need for large sample sizes to detect the small effects of practice and need to locate geographic areas where such a mix of physicians exist. Administrative database studies capture the full spectrum of practices and patients with sufficient sample size to demonstrate an effect. This study does not support the contention that in-hospital specialist care resulted in a unique mortality advantage. However, it is supportive of an advantage for high volume practice. Many studies addressing the relation between volume of procedures and patient outcomes have been published. [22-24] - most with respect to surgical care. Similar to our study, hospital size or the physician volume was used as a proxy for physician's skill. Community-acquired pneumonia unlike surgical volume studies is not associated with a unique procedure or skill. Treatment of pneumocystis pneumonia in HIV positive patients has been associated with improved outcomes when treated in higher volume centres [25]. Among studies analyzing hospital volumes and outcomes, better outcomes have been associated with higher patient volumes in some instances [26-29] but not others. [27, 30, 31] . Some studies of individual provider volume have shown a positive relation between volume and outcomes, [32, 33] whereas others have shown no relation or inconsistent results [22, 34]. Finally, only a few studies similar to ours have analyzed both

hospital volume and provider volume and reported a positive volume-outcome relation [35, 36].

This study does not specify what aspects of high volume care may be associated with decreased mortality. Specialist evaluation and treatment may be better because of greater conformity to published guidelines [37, 38]. It is not known if high volume practice conforms to treatment guidelines for community-acquired pneumonia. Early physician care documented as a pre-admission visit was associated with decreased in-hospital mortality, suggesting that expedient medical care is an important component of a care pathway for community-acquired pneumonia [2]. Although physicians were specified as the clinician involved with high volume, other health care workers may also be more skilled or more available where high volume practice is supported. This study, unlike others [39], did not find any association with decreased mortality at time when hospital staffing may be limited (weekends/holidays, 18:00 to 08:00). Another possible advantage to high volume care or pre-admission consultation is timely, appropriate antibiotic administration. [40, 41]. Finally, high volume practitioners may simply be better able to anticipate problems rather than react post occurrence. The ability to emulate high volume practice may represent another strategy to help physicians follow practice guidelines [42]. This may be particularly important as most cases of hospitalized pneumonia are cared for by primary care physicians in community hospitals [43]. This study does not specify why some of the hospital organization factors were associated with decreased mortality for community-acquired pneumonia mortality. The benefit of high volume hospitals may be related to better aftercare in the old and frail who are at greater risk of death rather than the specific treatment of the actual pneumonia.

Our study has several limitations. Population-based administrative database research is highly generalizable although limited in clinical details. We attempted to adjust for case severity and comorbidity, but may not have captured all variation [44]. These variables are likely less reliable than a clinically derived pneumonia index [2]. Processes of care variables, such as use of a special/intensive care unit or transfer to another hospital, are not justified by a specific threshold. As such, these variables would be expected to vary widely between patients and hospitals. Despite these limitations, the model's overall prediction of mortality was good as demonstrated by c-statistic. We were not able to uniquely identify physicians who practiced in more than one hospital. Therefore we could not credit combined case volumes to these multi-institutional physicians.

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FIGURE LEGEND

Figure 1 demonstrates in hospital mortality within the first twenty-four days of hospitalization.

Table 1 – Patient demographic and comorbidity factors (number and percent) for hospitalized community-acquired pneumonia in Alberta during April 1, 1994 to March 31, 1999

Characteristics	All pneumonia hospital discharges n=43,642	First 72 hour mortality for pneumonia hospital discharges n=1,311	All in-hospital mortality for pneumonia hospital discharges n=4,693	All cause one year mortality for pneumonia hospital discharges n=11,370
Female	21,070 (48.3%)	544 (41.5%)	1,954 (41.6%)	4,633 (40.7%)
Mean age and (standard deviation)	65.86 (19.70)	75.53 (15.12)	76.43 (13.99)	75.64 (13.99)
Median age	71	79	79	78
Aboriginal treaty status	2,966 (7.0%)	40 (3.1%)	105 (2.3%)	407 (3.6%)
Metropolitan region of residence	18,433 (42.2%)	716 (54.6%)	2,665 (56.8%)	5,837 (51.3%)
Comorbidity; mean (standard deviation)	1.06 (1.10)	1.64 (1.21)	1.87 (1.23)	1.71 (1.20)

Table 2 – Severity of illness for hospitalized community-acquired pneumonia (number and percent) in Alberta during April 1, 1994 to March 31, 1999

Illness factors	All pneumonia hospital discharges n=43,642	First 72 hour mortality for pneumonia hospital discharges n=1,311	All in-hospital mortality for pneumonia hospital discharges n=4,693	All cause one-year mortality for pneumonia hospital discharges n=11,370
Transfer from continuing care institution	4,422 (10.1%)	367 (28.0%)	1,032 (22.0%)	2,366 (20.8%)
Transfer to a larger acute hospital [1]	531 (1.4%)	N/A	N/A	173 (2.5%)
Transfer to hospital by ambulance	12,370 (28.3%)	743 (56.7%)	2,434 (51.9%)	4,974 (43.7%)
Weekend / holiday admission	12,113 (27.8%)	427 (32.6%)	1,401 (29.9%)	3,216 (28.3%)
Admission time between 18:00 to 08:00	18,759 (43.0%)	605 (46.1%)	2,126 (45.3%)	4,979 (43.8%)
Admission in December 1 to March 31 time period	18,884 (43.3%)	553 (42.2%)	1,924 (41.0%)	4,607 (40.5%)
Admission from emergency room	14,846 (34.0%)	444 (33.9%)	1,639 (34.9%)	4,014 (35.3%)
Emergent admission defined in hospital record abstract	12,514 (28.7%)	537 (41.0%)	1,755 (37.4%)	3,628 (31.9%)
Severity of presentation [2]	5,322 (12.2%)	514 (39.2%)	1,610 (34.3%)	2,420 (21.3%)

1 excluded those that died in hospital
2 any one of special care unit admission, hypotension/shock, in-hospital dialysis, respiratory arrest/failure, or ventilation for more than ninety-six hours

Table 3 – Hospital factors for community-acquired pneumonia in Alberta (number and percent) during April 1, 1994 to March 31, 1999

Hospital factors	All pneumonia hospital discharges n=43,642	First 72 hour mortality for pneumonia hospital discharges n=1,311	All in-hospital mortality for pneumonia hospital discharges n=4,693	All cause one year mortality for pneumonia hospital discharges n=11,370
Patient residence different region from hospital	5,247 (12.0%)	177 (13.5%)	510 (10.9%)	1,387 (12.2%)
Remote distance to local hospital	478 (1.1%)	3 (0.2%)	11 (0.2%)	57 (0.5%)
Rural hospital (less than 50 cases per year)	9,136 (20.9%)	183 (14.0%)	578 (12.3%)	1,841 (16.2%)
Rural hospital (50 to 108 cases per year)	9,367 (21.5%)	214 (16.3%)	702 (15.0%)	1,973 (17.4%)
Regional hospital	5,828 (13.4%)	167 (12.7%)	657 (14.0%)	1,482 (13.0%)
Urban hospital (metropolitan)	13,795 (31.6%)	519 (39.6%)	1,975 (42.1%)	4,318 (38.0%)
Urban hospital (hospitals in proximity to a medical school metropolitan)	5,516 (12.6%)	228 (17.4%)	781 (16.6%)	1,756 (15.4%)

Table 4 – Physician factors for hospitalized community-acquired pneumonia (number and percent) in Alberta during April 1, 1994 to March 31, 1999

Physician factors	All pneumonia hospital discharges n=43,642	First 72 hour mortality for pneumonia hospital discharges n=1,311	All in-hospital mortality for pneumonia hospital discharges n=4,693	All cause one year mortality for pneumonia hospital discharges n=11,370
General/family practitioner listed as most responsible physician	31,327 (71.8%)	780 (59.5%)	2,815 (60.0%)	7,439 (65.4%)
Any internal medicine specialist listed as consultant	18,325 (42.0%)	621 (47.4%)	2794 (59.5%)	6,064 (53.3%)
Patient volume per in hospital physician (1st quartile)	12,263 (28.1%)	379 (28.9%)	1,334 (28.4%)	3,130 (27.5%)
Patient volume per in hospital physician (4th quartile)	8,377 (19.2%)	291 (22.2%)	1,011 (21.5%)	2,390 (21.0%)
Pre-admission ambulatory visit by any physician (2 to 14 days prior to admission date)	18,145 (41.6%)	430 (32.8%)	1,650 (35.2%)	4,467 (39.3%)
Pre-admission ambulatory visit by an internal medicine specialist (2 to 14 days prior to admission date)	2,404 (5.5%)	78 (5.9%)	306 (6.5%)	783 (6.9%)
Emergency room claim between 2 to 14 days prior to admission date	3,910 (9.0%)	102 (7.8%)	374 (8.0%)	955 (8.4%)

Table 5 – Relationship between severity of illness, comorbidity, and physicians for community-acquired pneumonia in Alberta during April 1, 1994 to March 31, 1999

Characteristics	Mean (standard deviation) comorbidity	Mean (standard deviation) severity of presentation)
Patient volume per in hospital physician < 7(1st quartile) n=12,263 (28%)	1.01 (1.07)	0.15 (0.49)
Patient volume per in hospital physician of 7-13 (2nd quartile) n=12,408 (28%)	1.04 (1.08)	0.13 (0.46)
Patient volume per in hospital physician of 14-17 (3rd quartile) n=10,594 (24%)	1.01 (1.08)	0.14 (0.47)
Patient volume per in hospital physician of 28+ (4th quartile) n=8,377 (19%)	1.25 (1.19)	0.31 (0.69)
General/family practitioner as most responsible physician		
Yes n=31,327 (71.8%)	0.98 (1.05)	0.08 (0.32)
No n=12,315 (28.2%)	1.29 (1.19)	0.41 (0.81)
Any internal medicine specialist listed as consultant		
Yes n=18,325 (42.0%)	1.38 (1.20)	0.33 (0.72)
No n= 25,317 (58%)	0.83 (0.97)	0.06 (0.27)
Pre-admission consult by internal medicine consultant		
Yes n=2,404 (5.5%)	1.31 (1.14)	0.24 (0.61)
No n=41,238 (94.5%)	1.05 (1.10)	0.17 (0.52)
Pre-admission consult by any physician		
Yes n=18,145 (41.6%)	1.07 (1.10)	0.16 (0.50)
No n=25,497 (58.4%)	1.06 (1.10)	0.18 (0.54)

Table 6a – Logistic analysis for hospital death within the first seventy-two hours of admission

Factor group	Factor	Odds ratio (95% confidence interval)
Patient – severity of illness	Transfer to hospital from continuing care	2.5 (2.0-3.3)
Patient – severity of illness	Transfer to hospital by ambulance	1.8 (1.5-2.2)
Patient – severity of illness	Emergent admission	2.0 (1.7-2.5)
Patient – comorbidity	Comorbidity n = 1 [1]	1.9 (1.4-2.5)
Patient – comorbidity	Comorbidity n = 2 [1]	2.2 (1.6-3.1)
Patient – comorbidity	Comorbidity n > 2 [1]	3.0 (2.1-4.3)
Physician	With general practice/family physician as most responsible hospital physician	0.35 (0.27-0.47)
Physician	With internal medicine in-hospital consultant	0.45 (0.34-0.60)
Patient – comorbidity	Age group (45-64 years) [2]	2.4 (1.4-4.1)
Patient – comorbidity	Age group (65-74 years) [2]	2.5 (1.5-4.1)
Patient – comorbidity	Age group (75-84 years) [2]	2.4 (1.4-4.0)
Patient – comorbidity	Age group (85+ years) [2]	3.4 (2.0-5.8)
Patient – comorbidity	Female sex	0.81 (0.66-0.98)
Physician	Pre-admission ambulatory visit by an internal medicine consultant	0.55 (0.31-0.96)

[1] reference group is no comorbidity

[2] reference group is age group (eighteen to forty-four years)

The c-statistic for the model is 0.768 and they are 0.749 and 0.579 for patient factors alone and physician factors alone, respectively. No health care organizational factors were significant. Note that results are based upon one-third of the data. The order of factors indicate the relative strength of the explanatory power.

Table 6b – Logistic analysis for in-hospital death

Factor group	Factor	Odds ratio (95% confidence interval)
Patient – comorbidity	Comorbidity n = 1 [1]	2.4 (1.9-2.8)
Patient – comorbidity	Comorbidity n = 2 [1]	4.2 (3.5-5.1)
Patient – comorbidity	Comorbidity n >2 [1]	5.9 (4.8-7.3)
Patient – severity of illness	Transfer to hospital by ambulance	1.8 (1.6-2.0)
Patient – comorbidity	Age group (45-64 years) [2]	2.1 (1.5- 2.9)
Patient – comorbidity	Age group (65-74 years) [2]	2.6 (1.9- 3.6)
Patient – comorbidity	Age group (75-84 years) [2]	2.8 (2.1-3.9)
Patient – comorbidity	Age group (85+ years) [2]	4.5 (3.3-6.2)
Patient – severity of illness	Transfer to hospital from continuing care	1.8 (1.5-2.0)
Patient – severity of illness	Emergent admission from home/office/clinic	1.4 (1.2-1.5)
Physician	With general practice/family physician as most responsible hospital physician	0.58 (0.49-0.68)
Physician	Patient volume per in hospital physician of 7-13 [3]	0.85 (0.73-0.99)
Physician	Patient volume per in hospital physician of 14-27 [3]	0.91 (0.77- 1.1)
Physician	Patient volume per in hospital physician of 28+ [3]	0.59 (0.49-0.72)
Physician	With pre-admission consult by any physician	0.79 (0.70-0.89)
Patient – comorbidity	Female sex	0.81 (0.72-0.91)
Patient – comorbidity	Aboriginal treaty status	0.66 (0.46- 0.92)
Health care organization factor	Admission in December 1 to March 31 time period	0.85 (0.75- 0.95)
Health care organization factor	Admission time between 18:00 to 08:00	0.84 (0.75-0.95)
Physician	Internal medicine specialist in hospital consultant	1.23 (1.1-1.43)

[1] reference group is no comorbidity

[2] reference group is age group (eighteen to forty-four years)

[3] reference group is patient volume per physician (1st quartile)

The c-statistic for the model is 0.789 and they are 0.780, 0.626 and 0.517 for patient factors alone, physician factors alone and health care organizational factors alone, respectively. Note that results are based upon one-third of the data. The order of factors indicate the relative strength of the explanatory power.

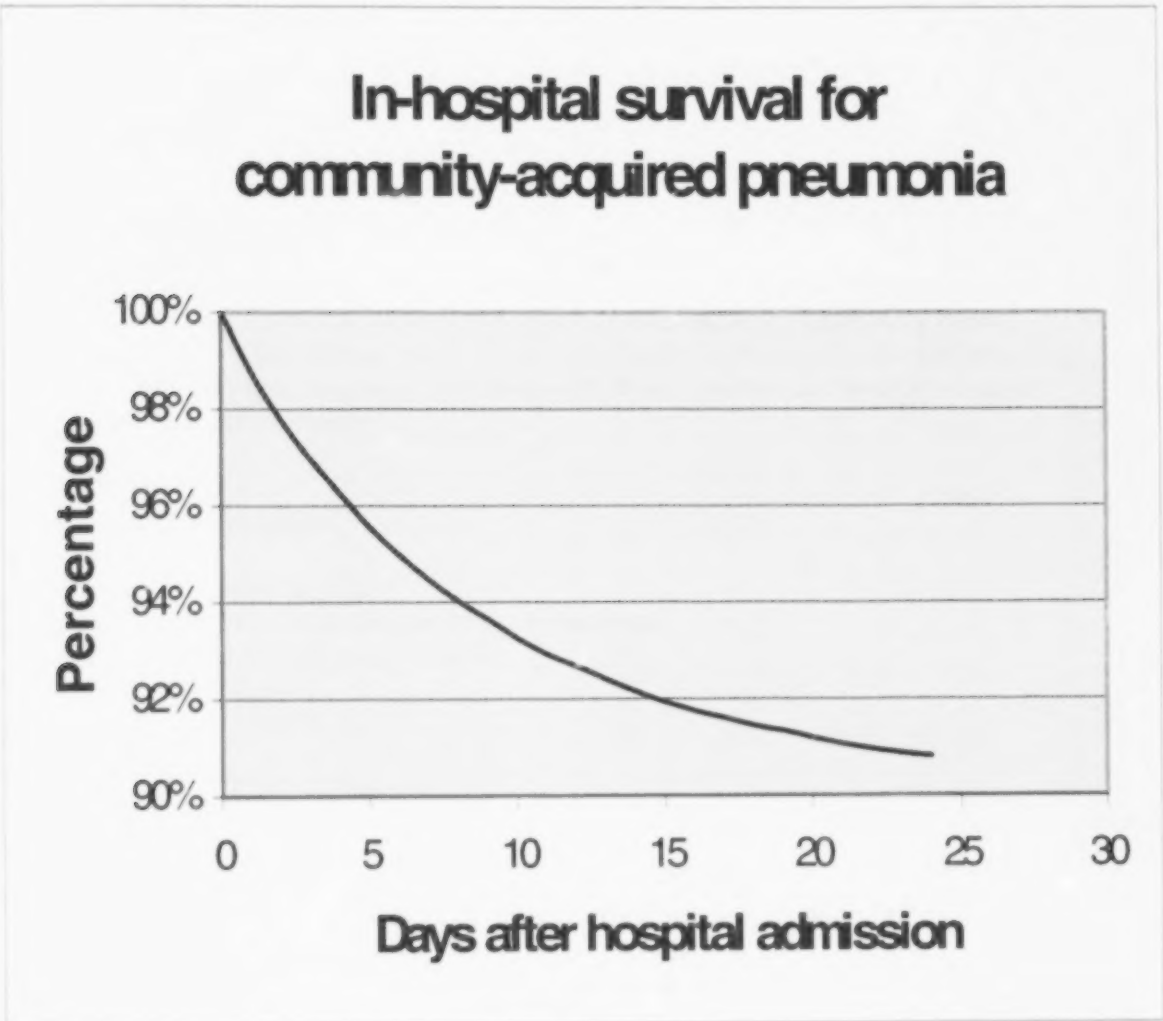
Table 6c – Logistic analysis for death at one year excluding all in-hospital deaths

Factor group	Factor	Odds ratio (95% confidence interval)
Patient –severity of illness	Transfer to hospital from continuing care	2.3 (2.0-2.7)
Patient –comorbidity	Comorbidity n = 1 [1]	2.2 (1.9-2.5)
Patient –comorbidity	Comorbidity n = 2 [1]	3.5 (3.0-4.1)
Patient –comorbidity	Comorbidity n > 2 [1]	4.8 (4.0-5.7)
Patient –comorbidity	Age group (45-64 years) [2]	2.6 (2.0- 3.3)
Patient –comorbidity	Age group (65-74 years) [2]	2.9 (2.3- 3.8)
Patient –comorbidity	Age group (75-84 years) [2]	4.0 (3.2-5.1)
Patient –comorbidity	Age group (85+ years) [2]	5.8 (4.5-7.4)
Patient –comorbidity	Female sex	0.66 (0.60-0.73)
Physician	With internal medicine in-hospital consultant	1.5 (1.27-1.68)
Patient –severity of illness	Transfer to hospital by ambulance	1.4 (1.2-1.5)
Health care organization factor	Patient residence different region from hospital	1.4 (1.2-1.6)
Health care organization factor	Admission in December 1 to March 31 time period	0.82 (0.74- 0.91)
Physician	With pre-admission consult by internal medicine specialist consultant	1.31 (1.1-1.6)
Physician	Patient volume per in hospital physician of 7-13 [3]	1.0 (0.89-1.2)
Physician	Patient volume per in hospital physician of 14-27 [3]	1.2 (1.0- 1.3)
Physician	Patient volume per in hospital physician of 28+ [3]	1.0 (0.84-1.1)
Health care organization factor	Admission to rural hospital [4] (50 to 108 cases per year)	0.91 (0.77- 1.1)
Health care organization factor	Admission to regional hospital [4]	0.74 (0.61- 0.89)
Health care organization factor	Admission to urban hospital [4] (metropolitan)	0.83 (0.70 – 0.99)
Health care organization factor	Admission to urban hospital [4] (hospitals in proximity to a medical school metropolitan)	0.95 (0.77 – 1.2)
Patient – severity of illness	Severity of presentation [5]	1.2 (1.1-1.4)
Health care organization factor	Admission day on holiday	0.84 (0.75-0.95)

[1] reference group is no comorbidity
[2] reference group is age group (eighteen to forty-four years)
[3] reference group is patient volume per physician (1st quartile)
[4] reference group is rural hospitals of (less than 50 cases per year)
[5] any of special care unit admission , hypotension/shock, respiratory arrest/failure, or in-hospital dialysis

The c-statistic for the model is 0.768 and they are 0.763, 0.578 and 0.569 for patient factors alone, physician factors alone and health care organizational factors alone, respectively. Note that results are based upon one-third of the data. The order of factors indicate the relative strength of the explanatory power.

Figure 1


In-hospital survival for community-acquired pneumonia
100%
98%
96%
94%
92%
90%
Percentage
0
5
10
15
20
25
30
Days after hospital admission

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